# Integration of Apollo Lunar Sample Data into Google Moon

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**The Google Moon Apollo Lunar Sample Data Integration project is a continuation of the Apollo 15 Google Moon Add-On project, which provides a scientific and educational tool for the study of the Moon and its geologic features. The main goal of this project is to provide a user-friendly interface for an interactive and educational outreach and learning tool for the Apollo missions. Specifically, this project's focus is the dissemination of information about the lunar samples collected during the Apollo missions by providing any additional information needed to enhance the Apollo mission data on Google Moon. Apollo missions 15 and 16 were chosen to be completed first due to the availability of digitized lunar sample photographs and the amount of media associated with these missions. The user will be able to learn about the lunar samples collected in these Apollo missions, as well as see videos, pictures, and 360 degree panoramas of the lunar surface depicting the lunar samples in their natural state, following collection and during processing at NASA. Once completed, these interactive data layers will be submitted for inclusion into the Apollo 15 and 16 missions on Google Moon.**

## Nomenclature

| | | |
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| *AS3* | = | ActionScript 3.0 |
| *EVA* | = | Extravehicular Activity |
| *HTML* | = | Hypertext Markup Language |
| *IRG* | = | NASA Ames Intelligent Robotics Group |
| *KML* | = | Keyhole Markup Language |
| *LRL* | = | Lunar Receiving Laboratory |
| *LRV* | = | Lunar Rover Vehicle |
| *ULCN* | = | Unified Lunar Control Network |
| *URL* | = | Uniform Resource Locator |
| *XML* | = | Extensible Markup Language |
| *WWJ* | = | World Wind Java |

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## I. Introduction

As technology has developed over the past 40 years since the first Apollo mission, scientists and researchers have been working to preserve the information collected from these historic missions. The digitization of the Apollo era documents and photographs is, to this day, an ongoing project that will take many years to complete. In the Astromaterials Acquisition and Curation department at NASA Johnson Space Center, several projects are underway to digitize and preserve data pertaining to the rock samples collected during the Apollo missions. The types of data being digitized by NASA range from photographs and video documenting the collection of lunar samples from the Moon's surface to sample catalogs, sample processing documentation and photographs taken in the Lunar Receiving Lab (LRL), and scientific data about the composition of these samples. When completely digitized, the collection will serve as a database for lunar sample collections, making information retrieval much simpler.

The Apollo Project provides an overview of the lunar samples collected from the Apollo 15 and 16 missions to be integrated into Google Moon. The lunar samples are presented by way of a lunar sample gallery, and are organized by station collection site for each of the missions. In order to conform to Google's layout for Google Moon, the gallery templates were used for uniformity. Each of the station collection sites in Apollo 15 and 16 have a gallery that presents the user with information about the site, a link to an interactive station map, and a large selection of lunar sample thumbnails that direct the user to the informational pop-up for a particular sample. The interactive station feature is a means to present the user with an expandable menu for each of the lunar samples found at the collection site. Therefore, there are many options to the user to find the most information on these missions and the lunar samples collected.

The Google Moon Apollo Lunar Sample Data Integration project is a continuation of the Apollo 15 Google Moon Add-On project from 2009, which entailed creating individual lunar sample informational pop-ups for each lunar sample collection station near the Hadley Rille in Google Earth, superimposed on a Moon surface photo layer created by the NASA Ames Intelligent Robotics Group (IRG) [1] from Clementine and Apollo orbital photography. At the time, Google Moon was unavailable to the public so the layer was developed to serve as an overlay in Google Earth. During the earlier project, each lunar sample was georeferenced using drawn station maps from the **APOLLO 15 PRELIMINARY REPORT**[2], which were created immediately following the return of the lunar samples to the Lunar Receiving Laboratory (LRL). Once georeferenced, a simple place mark system was used to place the lunar samples onto Google Moon. In addition to the pop-ups made for the lunar samples, pop-ups were also created to describe the station at which they were found. Video footage edited by the University of Texas at El Paso (UTEP) Geology Department[3], high-resolution photographs, and 360-degree panoramas were added to these station pop-ups for the fullest experience of the moon.

In the time since this initial project was completed, Google has released Google Moon as an integrated part of Google Earth, allowing us to take advantage of the new tool to create our new data layers. The new project was designed to be integrated directly into Google Moon as part of the native Apollo mission layers created by Google and NASA Ames[4]. In order to preserve the look and structure of the data layers within Google Moon, Google has provided a template for the format to follow for the different types of content for the data layer. All available media, including the video footage, high-resolution photographs, and 360-degree panoramas were merged from the previous version of the project into the new data layer for Apollo 15, and new content was created for Apollo 16 following the same format used for the Apollo 15 layer and the **APOLLO 16 PRELIMINARY REPORT**[5]. Along with incorporating the ideas and work from the original project, this version is much more interactive. The new design of the Apollo Google Moon data layers gives the user more of a selection when inquiring about lunar samples. Users can view sample information through photo galleries, pop-up windows, interactive station maps, or directly through place marks on station overlays on the Moon's surface. Each of the rock samples for Apollo 15 and 16 have an associated interactive button within a station, which holds links to a great deal of resources. These interactive station maps show the basic structure of each sampling site for the mission. Locations of the lunar samples, features around the sampling site, and the area where the Rover was parked are found on these maps. The interactive portion is for the lunar samples; the user may click on a red X mark to view a menu for the sample. The stations and samples are put together in a much more organized fashion than in the previous add-on application.

Upon completion, the Google Moon Apollo Lunar Sample Data Integration Project is designed as an outreach vehicle to fit the needs of a wide range of users. The historic perspectives of the application will provide a learning tool for teachers to use in the classroom and a comprehensive data source for scientists, students, and the general

public and the interactive features of the program will serve as a user-friendly hands-on tool with applications to satisfy the casual user as well as the serious researcher. On the other hand, the program will also aid in the geological aspects of astronaut training for our eventual return to the moon. The Google Moon Sample Data Layer is an excellent complement to geological training because it will exhibit the surroundings of each lunar rock sample retrieved, enabling the astronaut to better recognize such features when executing geological excursions on the Moon. Each of the mission sites will have panoramic images of the area and video footage where applicable, which will provide a visual aid during training.

## II. Design of the Apollo Sample Collection Data Layers

One of the goals of this project is to take the user through a scientific exploration of the lunar surface. During the Apollo missions, a few of the many tasks of the astronauts included: taking panoramic photographs, taking high-resolution photographs of the lunar samples in their natural environment prior to collection, and describing their surroundings. The Google Moon Apollo Sample Collection project is designed to fully utilize these resources, and compile them, station by station inside of Google Moon. The direction has shifted, only slightly, from the last year's project. The content included in the original Apollo 15 Sample add-on is also used in the new data layers, but the content itself has been redesigned to be more interactive than last year. The rationale for this enhancement is to give the user more control over the application.

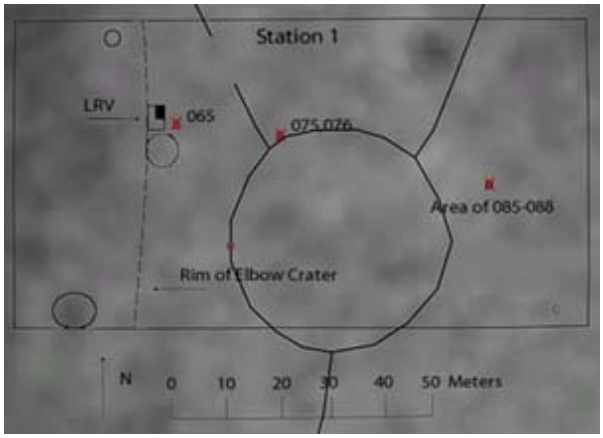


**Figure 1 Station Map Overlay in Google Moon**

The interactive features are much more straightforward than what was found in the add-on project, and are organized a bit differently. For example, place marks for the lunar samples are still located within their corresponding station in Google Moon, but a station map overlay has been added for easier visualization. As seen here in Figure 1, the station map overlay shows the user some of the features surrounding the lunar samples, as well as the sample number for the samples collected in this station. In addition, interactive station maps on the "balloon" pop-ups give users a way to click on a sample to view a menu of options for navigating to additional sample content and media.

This version of the project now includes both Apollo 15 and 16 sample data. Most of the information created in the original project was utilized for the Apollo 15 mission in this project with extensive additions to the data set from newly available sources. All of the mission information for Apollo 16 was created separately this year so that it includes the same features and information included in the newly redesigned Apollo 15 layer.

There have also been new features added to each of these Apollo missions. Interactive station maps with sample locations provide the user with the basic layout of each of the collection sites, and buttons for each of the lunar samples expand into a menu for the user to choose from. These station maps, which were updated from the station maps made in the 1970s, were also used as an overlay on the Google Moon surface. This gives the user a perspective with respect to the lunar surface of where the rock samples were taken. Station media and sample galleries were also included for better organization. This method allows the user to toggle between lunar samples or choose a sample from the gallery. When the user chooses a particular sample, an informational pop-up is displayed with links to other resources, including the sample catalog, compendium (where applicable), and an additional gallery of photographs for this particular sample. This gallery holds photographs of different faces of the rock, thin sections, and a surface photograph prior to collection. In addition to the lunar samples in the gallery, links to annotated panoramas were added. These annotations were included to show the user where each of the samples were located prior to collection inside of the panoramas.

# III. Technical Implementation

## A. Interactive Station Maps

The hand-drawn station maps created after the Apollo missions were originally scanned but had low resolution and needed to be remade. Using Adobe Fireworks CS5[6], all of the station maps from Apollo 15 and 16 were redrawn and placed as bitmaps into Adobe Flash CS5[7]. Adobe Flash CS5was then used to make interactive station maps for Apollo 15 and 16. Inside of Flash, interactive buttons were created for each of the lunar samples in a collection station. These interactive buttons were placed onto the "stage", where they can be played as a movie as it runs through a timeline. This was the method used to create the station maps that are seen on Google Moon.

The coding inside of Flash is done in ActionScript 3.0 (AS3), an Adobe-proprietary object-oriented programming language similar to Java. Using AS3, the developer is able to add functions to each of the buttons on the stage, and also run commands as the movie is played. Coding was used to add URL links to each of the buttons, including links to the lunar sample catalog pages, high-resolution photographs of the lunar samples before sampling, and astronaut commentary associated with each of the samples.

Figure 2 shows an example of an interactive station map for Apollo 15 Station 6. All of the red X marks are lunar sample locations within the station. When a user rolls their mouse over these X marks they see the sample number, as indicated by the text box "Sample 15245". By using this feature instead of placing the sample numbers directly on the station, text crowding is avoided in stations with lots of samples. Once a sample is clicked on, a menu around the sample opens so the user can learn more about the particular rock. The four choices are described below.

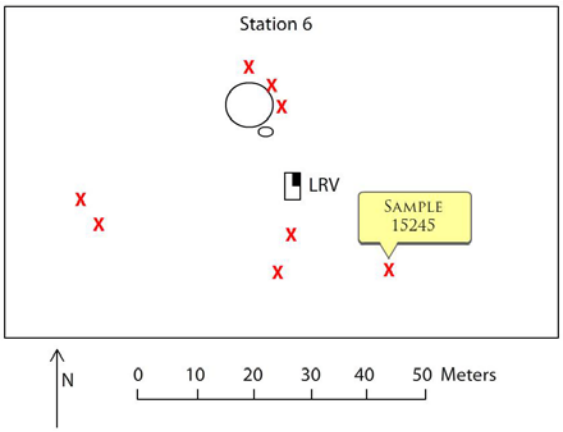


**Figure 2 Interactive Station Map of Apollo 15 Station 6 Using Flash Technology**

1. *Sample Information*

   Currently, this link is directed to a lunar sample's catalog page on the Astromaterials Curation website. In the future, the "Sample Information" option may be changed to direct the user to the sample's informational pop-up directly in Google Moon. From there, the user can decide to go on to the catalog page, the lunar sample compendium or read the simple description provided in the pop-up.

2. *Surface Photograph*

   This option directs the user to a photo in which the lunar sample can be seen before it was taken from the lunar surface. Every photograph was annotated to show the precise location of the sample on the lunar surface and the sample number assigned. This feature was added to give the user more information about the environment in which the sample was collected. There is not a surface photograph for every sample, unfortunately, but this feature is available for most samples.

3. *Astronaut Commentary*

   Once clicked, this option takes the user to NASA's Headquarter History page[8,9] to view astronaut commentary about a particular sample. Like the "Surface Photograph" menu option, commentary is not available for each lunar sample.

*4. Movie*

This feature has not been added yet. Once the editing has been completed for all video footage from both Apollo 15 and 16, the footage will be integrated into this project. The content for this feature is being provided as part of a separate NASA project and selected clips will show video of the sample as it is collected from the Moon along with commentary and footage of sample processing at the Lunar Receiving Lab.

Figure 3 shows what can be seen when a lunar sample is chosen on the interactive station maps. Each of the surrounding buttons are currently linked to web pages containing additional resources or media, but once the project becomes more advanced, these buttons will show the user an informational pop-up directly in Google Moon.

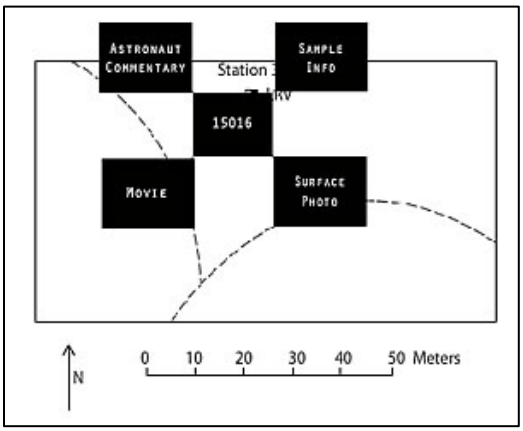


**Figure 3 Sample Menu Options**

## B. Station Map Overlays

Another new feature of this project is the layout on Google Moon. In the previous project, the user had to zoom in to the station area and find the lunar sample desired. Now, once the mission is selected, Google Moon flies to the mission area, which displays the Mission's landing area, EVA traverse routes, and overlays of the station maps for sample collection areas for the Mission. The station areas also contain place marks identifying the locations of samples collected, as well as other notable features of the area.

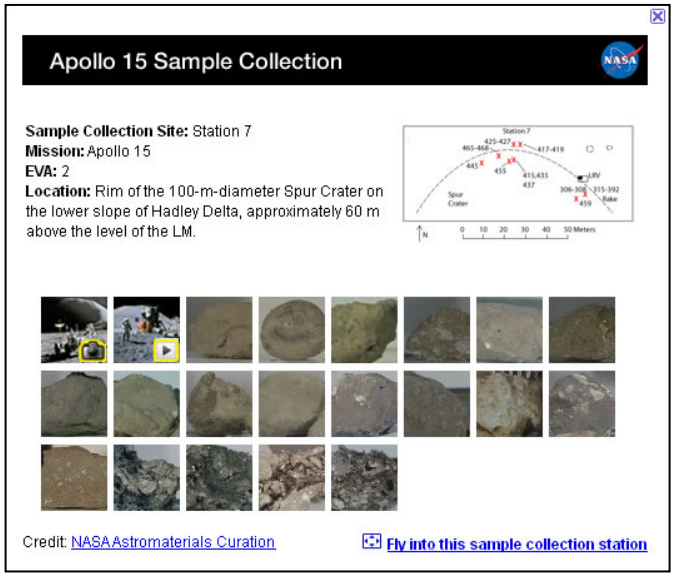


**Figure 4 Station Overview Media Gallery**

## C. Station Media Galleries

Selecting a station from the sidebar flies the user to the station area and opens an overview pop-up containing a media gallery for the station and a link to the interactive station map. This overview pop-up shows thumbnails connecting to all panoramas, video clips, photographs and sample resource pages for that station. Figure 4 shows a typical media gallery for a station. Each thumbnail triggers a pop-up window showing the media available and additional information. There is also a larger thumbnail connecting the user directly to the interactive station map.

An interesting factor in the project is the interactive media associated with the stations. Each of the stations has at least one of three media types associated with it: a video clip of the astronauts on the lunar surface, edited by the University of Texas at El Paso (UTEP), a stitch of high-resolution photographs of the station area, or a 360° interactive panorama. The following describes the types of media available.

*1. Video footage*

A group from the Department of Geological Sciences at UTEP was funded by NASA to digitize and edit Apollo videos for educational purposes. They provided both raw and edited footage for Apollo 15, and that was used in this project. The edited video provided by UTEP includes commentary describing the sequence of events. The commentary includes explanations of experiments conducted on the lunar surface and of the lunar samples the

astronauts picked up. Some of UTEP's formatted videos, associated with their corresponding stations, are currently available on youTube. Google Moon holds the ability to embed video footage, so the videos were embedded directly into "balloon" pop-ups.

*2. Stitched photographs*

If the consecutive photographs used to make a panorama are not sufficient, a stitch of just a few high resolution photographs is used instead. This gives a better view than that of a single photograph. Stations with stitched photographs have no available video footage associated with them, nor did they have desirable photographs to use for a 360° panorama. These stitched images were obtained from the Apollo Lunar Surface Journal, a NASA Headquarters website.

**Figure 5 Panorama View Showing Sample Locations as Clickable "Hotspots"**

*3. 360° Panorama*

This feature is the most interactive part of the Apollo project. One of the tasks of the astronauts of the Apollo missions was to take consecutive photos of their surroundings to be later assembled into panoramas. These panoramas enable the user to look around a particular station and view their surroundings. This feature could be beneficial for astronaut training for simulating the view of the lunar surface as seen through the eyes of the astronaut who took the original image.

Panoramas were assembled and organized, by mission, on NASA Headquarters' website. All of these assembled panoramas are flat, but enable the viewer to see the entire area surrounding the astronauts. This project utilizes these photographs, but instead, uses a program called PanoramaStudio[10] to stitch together each of the consecutive photographs that make up the panorama. In doing this, it produces a 360°, spherical panorama that enables the user to "look around" manually by turning the panorama. Other features of this panorama view include automatic play and zoom in/out.

A new feature that has been added to this project is embedding 'hotspots' into the panoramas. As seen in Figure 5, these hotspots show the user exactly where a lunar sample is if it can be seen within the panorama, by placing an arrow over the sample. If clicked on, the hotspot takes the user to the lunar sample catalog page for that rock. This feature, by default, is turned off once the panorama is opened. The user can turn the hotspot function on by clicking the hotspot button on the play bar of the panorama. This feature was added so the user can have an idea of where the sample was found, as well as its surroundings before it was picked up by an astronaut.

**D. Sample Information Resources and Media Gallery**

The sample informational pop-ups have been changed as well to include a gallery of photographs for the lunar sample. As seen in Figure 6, the sample has a main photograph and a gallery below with different views of the sample, thin section pictures, and a photograph of the sample prior to being picked up. The user can view all of the samples in this way, by clicking "Previous" and "Next" to toggle between lunar samples for the collection site. The "Overview" button takes the user back to the station gallery.

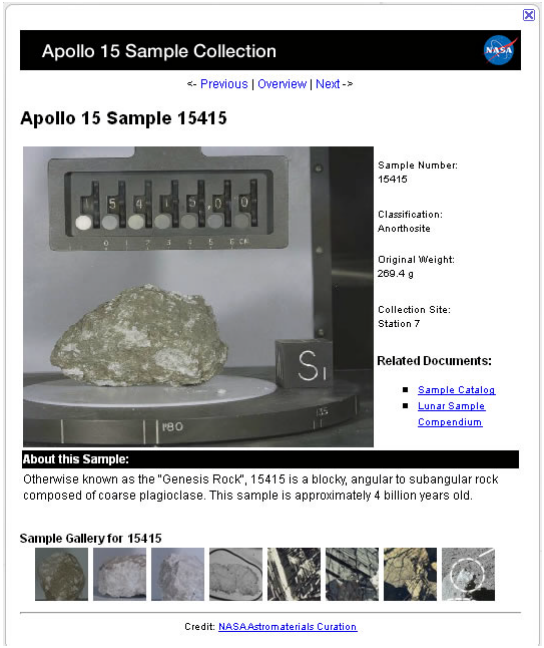


**Figure 6 Sample Information Pop-Up and Gallery**

## IV. Conclusion

The Apollo project was developed to be an interactive view of historical mission information for the general public through the Google Moon application. From the initial stages of the project as an add-on, to the present project of a direct integration into Google Moon, this project has been enhanced from its beginning stages through georeferenced, high resolution images from NASA Ames Intelligent Robotics Group and rebuilt for Google Moon.

This project is a contribution to a larger project of digitizing all Apollo era data. The preservation of this important information is crucial as decades pass since these missions. So far, many of the paper copies of catalogs of the lunar samples have been digitized into PDF format for the web. These sample catalog pages have been linked inside of the new interactive station maps created for Google Moon. Inside of these interactive station maps are links to video footage, astronaut transcripts, surface photography, and the sample catalog pages.

Each station in Apollo 15 and 16 have station galleries associated with them, which present the user with several options for viewing the lunar samples. The thumbnail feature allows the user to click directly on a sample, which brings up the informational pop-up for that particular sample. The user may toggle between samples by clicking "Previous" or "Next", or return to the gallery by clicking "Overview". This enhances the organization of the lunar samples, and allows easier navigation through the stations.

The media options have also been modified to provide a more scientific approach to learning about the lunar samples. Hotspots have been embedded into the 360 degree panoramas to display the locations of the lunar samples on the surface before being sampled, which complements the interactive station maps that show the locations of these samples. The raw video footage has been edited by our partners at UTEP to provide explanations of each of the lunar samples.

In general, the Apollo project for the Google Moon application will serve as a beneficial tool for looking into the past, and preparing for the future, of lunar exploration.

## Acknowledgments

Many people aided in the development of this project. First, I would like to acknowledge Dr. Carlton Allen, Manager and Astromaterials Curator, for allowing me to intern with the Astromaterials Curation group, and Dr. Gary Lofgren, Lunar Sample Curator, for providing excellent feedback for this project. Mrs. Nancy Todd, my mentor and the IT Projects Technical Lead, is greatly acknowledged for her great computer skills and creativity, and is a fellow developer of this Apollo project. Fellow interns Kristina Mullins and Brett Jorden also contributed to this project, while this project was still WorldWind Java. I would also like to acknowledge the Undergraduate Student Research Program (USRP), who gives such a great opportunity to students to intern at NASA. The NASA Ames Intelligent Robotic Group and Google also deserve acknowledgment for their excellent Traverse Planning files, including the KML they allowed us to use for development of this project. The group at UTEP, who has edited the Apollo 15 video footage, is also acknowledged for providing a great geological tool to the users of this project. Also, I would like to provide a widespread appreciation for every contribution, both big and small, to this great educational tool for historical and geological enthusiasts.

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